

# Fishes of the Waccamaw River Drainage

JOHN R. SHUTE<sup>1</sup>, PEGGY W. SHUTE<sup>1</sup> AND DAVID G. LINDQUIST

*Department of Biology,  
University of North Carolina at Wilmington,  
Wilmington, North Carolina 28406*

**ABSTRACT.**— From 1976 through February 1981, we made 827 collections of fishes from 75 stations in Lake Waccamaw and the Waccamaw River and tributaries; they yielded a total of 56 species from 18 families. Additional records increased the probable total to 62 species. At least five of the Waccamaw species are endemic or exclusively shared with one other drainage. These aspects of the Waccamaw indicate that it is unique among Atlantic Coastal Plain drainage systems. Geological and zoogeographical evidence suggest that the Waccamaw River once drained a larger area extending into the inner Coastal Plain and Piedmont. Uplifting of the Cape Fear Fault resulted in piracy of the Waccamaw headwaters, creating the present Cape Fear drainage. Faunal resemblances between the drainages lend support to this theory.

## INTRODUCTION

Since the description of the Waccamaw killifish, *Fundulus waccamensis*, silverside, *Menidia extensa*, and darter, *Etheostoma perlongum*, by Hubbs and Raney (1946), Lake Waccamaw, North Carolina, has been the subject of both biological and physiographical studies (Frey 1948a,b, 1949, 1951) alluding to the relatively high level of fish diversity and endemism. Louder (1962a) provided a checklist of fishes and Hueske (1948) discussed fishery resources. Four species from the lake have been subjects of biological studies: *Notropis petersoni* (Davis and Louder 1971); *F. waccamensis* (Shute et al., ms.); *M. extensa* (Davis and Louder 1969); and *E. perlongum* (Lindquist et al. 1981; Shute et al., in press).

Apart from those of the lake, the fishes of the Waccamaw drainage have received little attention. Louder (1962b) included the Waccamaw drainage in a survey of the Lumber and Shallotte River drainage in North Carolina, and the major purpose of his survey was to evaluate the recreational fishery potential. Fowler (1935) reported on several collections from the Waccamaw drainage in South Carolina.

The Waccamaw is unique among Atlantic coastal drainages. Its overall fish diversity is quite high and includes a number of endemics and forms shared with but one other drainage. Presently two undescribed species of fish are known to occur within the Waccamaw drain-

<sup>1</sup> Present address: Department of Zoology and Entomology, University of Tennessee, Knoxville, TN 37916.

Direct reprint requests to DGL.

age. Seventeen species of plants and animals considered of special concern by biologists were listed from in and around Lake Waccamaw by Teulings and Cooper (1977). Parts of the Waccamaw River's upper reaches have been proposed for inclusion in the National and Scenic Rivers System (Anonymous 1978) because of their relatively undisturbed nature and the river's unique assemblage of flora and fauna.

Geological evidence suggests that the Waccamaw River once drained a much larger area, extending into the inner Coastal Plain and Piedmont. As discussed later, zoogeographical evidence supports this theory, which may explain the high species diversity.

This study was intended to provide a baseline of information on the overall distribution of fishes within the drainage, with special emphasis on the endemic and undescribed forms, because habitat alteration could present a definite problem for most of the unique fishes. There is limited suitable habitat for the species with upland affinities, and impoundment or channelization projects could prove disastrous.

### STUDY AREA

The Waccamaw River drainage lies entirely within the low Coastal Plain of North and South Carolina, draining an area of approximately 4000 km<sup>2</sup> (Fig. 1). It is a relatively young system, believed to have been formed during the Late Pleistocene, 32,000 to 75,000 years ago (Zullo and Harris 1979). Sediments consist of Pleistocene sands underlain by the fossiliferous Waccamaw Formation, a limestone formation that is exposed in some areas of the river. The Surry Scarp forms the western border of the system, and to the north the Cape Fear Fault forms a barrier separating the Cape Fear Basin from the Pee Dee Basin (Zullo and Harris 1979).

### FRIAR SWAMP

Friar Swamp is the principal feeder system to Lake Waccamaw. Originating from Council Mill Pond (approximately 15 km north-northwest of Lake Waccamaw), this small stream flows south and converges with Slap Swamp, Buckhead Branch, and Gum Swamp to form Big Creek (Fig. 1). Big Creek is a typical blackwater stream with a sandy, muck bottom and an abundance of aquatic vegetation along its shoreline.

### LAKE WACCAMAW

Lake Waccamaw is the largest of the Carolina Bays, with a total area of 3618 ha. Most of its 22.9 km shoreline is characterized by sandy, low-gradient beaches. Vast beds of maidencane, *Panicum hemitomum*, extend offshore along the eastern, southern, and western shores of the lake. Cape Fear spatterdock, *Nuphar luteum sagitifolium*, grows in

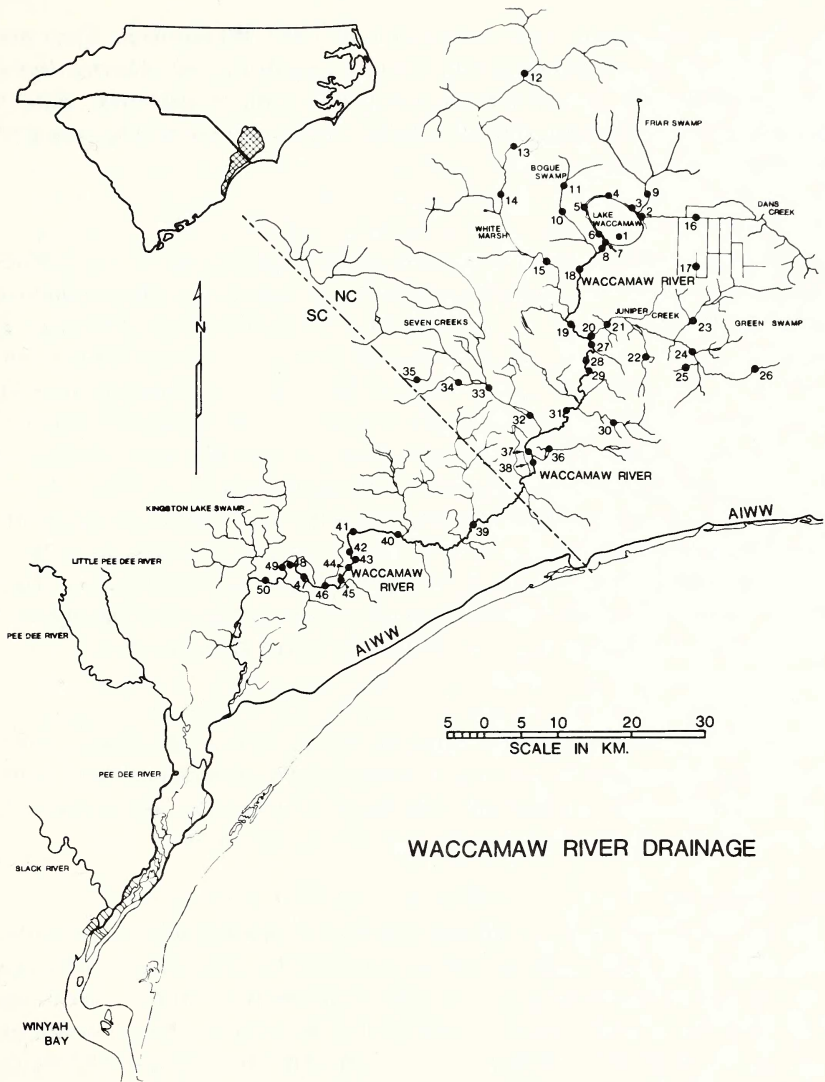


Fig. 1. Map of the Waccamaw River drainage, North and South Carolina, showing fish sampling localities.

dense beds off the northern and northeastern shores. The bottom is mainly sand and fibrous peat. Over the peat bottom, generally toward the middle of the lake, thick stands of bushy-pondweed, *Najas guadalupensis*, occur and a green alga, *Nitella* sp., is seasonally abundant. Average depth of the lake is 2.3 m, and maximum depth is 3.3 m.

In addition to Big Creek, the lake is fed by three smaller streams: Little, Second, and Third creeks. Acid water from these streams is neutralized by the calcareous Waccamaw limestone formation, which underlies the lake and is exposed along the north shore (Frey 1951).

Man-made canals surround much of Lake Waccamaw. They are characterized by dense vegetation (mainly alligator-weed, *Alternanthera philoxeroides*; duckweed, *Lemna perpusilla*; and beggar tick, *Bidens laevis*) and steep, grassy roadside banks, and are open to the lake and the Waccamaw River.

#### WACCAMAW RIVER

The Waccamaw River originates at the south shore of Lake Waccamaw and flows southward approximately 225 km to its confluence with the Pee Dee River at Winyah Bay, South Carolina. The river is sluggish and meandering with an average gradient of only 6.44 cm/km. Above Juniper Creek (Fig. 1), much of the river is less than 15 m wide with the exception of an area known locally as "The Fishponds," located just below Bogue Swamp. Here, for a distance of several hundred meters, the river widens to approximately 50 to 60 m. Below Juniper Creek the river widens considerably, and before crossing the North Carolina/South Carolina state line averages around 75 m wide.

Seasonally, water levels in the river fluctuate considerably. High water occurs in late winter and throughout the spring. During summer and fall the waters recede, creating shallow, sandy stretches.

#### BOGUE SWAMP

Bogue Swamp is the first tributary to the Waccamaw River, originating approximately 6.5 km northwest of Lake Waccamaw and flowing 13 km southeast before entering the river (Fig. 1). This is a small, sand-bottom stream, often intermittent during dry months.

#### WHITE MARSH

Brown Marsh, Elkton Marsh, and Red Hill Swamp flow from the upper part of White Marsh, approximately 23 km northwest of Lake Waccamaw. White Marsh is a sluggish, muck-bottom stream that flows southeast for 33 km before entering the Waccamaw River. Stations sampled during our survey were in Red Hill Swamp and the main stream of White Marsh (Fig. 1). Aquatic vegetation was dense in the areas collected, and station 15 was heavily obstructed with roots, stumps and water-logged branches.

#### JUNIPER CREEK

Juniper Creek is the largest tributary to the Waccamaw River in North Carolina and is the first to enter the river from the east (Fig. 1). It is formed by the confluence of Muddy Branch and Bear Pen Island, Honey Island and Alligator swamps. Juniper Creek and its tributaries form the major drainage system for Green Swamp. Many interconnecting man-made canals east of Lake Waccamaw join Honey Island Swamp with Dans Creek of the adjacent Cape Fear Drainage. These

canals are normally 3 to 5 m wide and 1 to 2 m deep.

Upper Juniper Creek is generally narrow (6 to 8 m) and shallow, and flows year-round. The channel widens to approximately 25 m downstream and becomes sluggish. Before reaching the river it again narrows and flow increases. Much of this stream is characterized by sand bottom and patches of dense aquatic vegetation. The wide, sluggish areas are generally richer in organic debris, and sphagnum moss, *Sphagnum* sp., grows in dense mats along the shoreline. Juniper Creek flows west approximately 35 km to its junction with the Waccamaw River.

#### SEVEN CREEKS

The headwaters of Seven Creeks are formed by Toms Fork, Mill Branch, and Juniper, Brissett, Gum, Beaver Dam, and Monie swamps. This predominantly muck-bottom stream flows approximately 16 km southeast until reaching the Waccamaw River 13 km above the North Carolina/South Carolina state line. Areas sampled were clogged with a tangle of old tree stumps, roots, and waterlogged branches. Aquatic vegetation was present but not dense.

Many smaller tributaries not discussed also flow into the Waccamaw River. During our survey, no South Carolina tributaries were sampled. Kingston Lake Swamp forms the largest of the Waccamaw River tributaries above the Atlantic Intracoastal Waterway (AIWW). Several small streams and canals connect the Waccamaw and Pee Dee rivers before their confluence at Winyay Bay.

#### METHODS

From January 1979 through February 1981 a total of 827 collections was made from 75 stations within the Waccamaw River drainage (Table 1). Stations 1a through m, 2a,b,c, 3, 4, 5, 6, and 7 were sampled monthly during this period. The remaining stations were sampled on an irregular basis, sometimes only once. Six of the mid-lake stations in Lake Waccamaw are treated as one throughout this paper (Station 1i).

Most collections were made with seines varying in size from 3 m  $\times$  1.2 m to 15.2 m  $\times$  1.8 m, typically with 3 mm mesh. Offshore stations in Lake Waccamaw (and one Waccamaw River station) were sampled with a small otter trawl measuring 2.8 m  $\times$  1.3 m at the mouth and lined with 3 mm mesh. Dip nets of various sizes were also used. A representative sample of fishes was usually field preserved in 10% formalin and later stored in 70% ethanol. Large or extremely common species were occasionally returned to the water (some were photographed before release) and records are based on field identifications. Museum specimens and literature records were verified where possible.

Nomenclature follows that used by Robins et al. (1980). Most specimens are housed in the University of North Carolina at Wilmington Fish Collection (UNCW).

Table 1. Sampling stations. US = U.S. highway, CR = county road; NC = N.C. highway.

## NORTH CAROLINA

### COLUMBUS COUNTY

- 1a. Lake Waccamaw, north shore public beach on NC 214.
- 1b. Lake Waccamaw, northeast shore at Hobbs Harbor on NC 214.
- 1c. Lake Waccamaw, northeast shore just west Big Creek.
- 1d. Lake Waccamaw, southeast shore at northern boundary state park.
- 1e. Lake Waccamaw, south shore at southern boundary state park.
- 1f. Lake Waccamaw, south shore just east dam.
- 1g. Lake Waccamaw, south shore just above dam.
- 1h. Lake Waccamaw, southwest shore.
- 1i. Lake Waccamaw, mid-lake.
- 1j. Lake Waccamaw, north offshore transect.
- 1k. Lake Waccamaw, north offshore transect.
- 1l. Lake Waccamaw, northeast offshore transect.
- 1m. Lake Waccamaw, south offshore transect.
- 2a. Big Creek Wildlife Access Area on SR 1947.
- 2b. Big Cr. trib. at second bridge going east on SR 1947.
- 2c. Big Cr. at first bridge going east on SR 1947.
3. Waccamaw canal, northeast shore lake on SR 1947.
4. Waccamaw canal, north shore lake on NC 214.
5. Waccamaw canal, northeast shore lake at junction NC 214 and SR 1957.
6. Waccamaw canal, southwest shore lake.
7. Waccamaw River just below dam on south shore lake.
- 8a. Waccamaw R. from below station 7 to approx. 1.6 river km below lake.
- 8b. Waccamaw R. between 1.6 and 3.2 river km below lake.
- 8c. Waccamaw R. between 3.2 and 4.8 river km below lake.
- 8d. Waccamaw R. between 4.8 and 6.4 river km below lake.
9. Big Cr. at bridge on US 74-76, 4.4 km W Lake Waccamaw.
10. Bogue Swamp, 1.6 km ESE Hallsboro on CR 1736.
11. Bogue Swamp, 1.2 km E Hallsboro on US 74-76.
12. Red Hill Swamp, 16.1 air km N Whiteville on CR 1700.
13. White Marsh trib., 6.4 air km NNE Whiteville on CR 1700.
14. White Marsh, 3.2 km E Whiteville on US 74-76.
15. White Marsh, 8 air km S Hallsboro on CR 1001.
16. drainage canal, 2.4 km S Bolton on NC 211.
17. drainage canal, 9.2 km S Bolton on NC 211.
18. Waccamaw R. at Crusoe Island, 4 air km NE Old Dock.
19. Waccamaw R., 2.4 air km SE Old Dock on CR 1928.
20. Brunswick Co. line; Juniper Cr., oxbow just above confluence Waccamaw R., 4.8 air km ESE Old Dock.

21. Juniper Cr., overflow pond on CR 1928, 5.6 air km ESE Old Dock.
31. Waccamaw R., 7.2. air km NE Pireway, "Reeve's Ferry."
32. Seven Crs., approx. 1.6 km N Pireway on NC 905.
33. Seven Crs., 8 air km NW Pireway on CR 1108.
34. Juniper Swamp, 13.7 air km NW Pireway on CR 1118.
35. Toms Fork, 12.9 air km SE Tabor City on CR 1119.
37. Brunswick Co. line; Waccamaw R., 1.6 air km SE Pireway on NC 904.
38. Brunswick Co. line; Waccamaw R., 1.6-9.7 river km S of NC 904 bridge.

## BRUNSWICK COUNTY

22. Aligator Swamp, just N Exum on CR 1335.
23. Big Swamp, 17.7 km S Bolton on NC 211.
24. Juniper Cr., 1.6 air km E Makatoka on CR 1340.
25. Juniper Cr. trib., 3.5 air km SE Makatoka on Cr 1342.
26. Juniper Cr., 29.8 km S Bolton on NC 211.
- 27a. Columbus Co. line; Waccamaw R. just below confluence Juniper Cr., 5.2 air km SE Old Dock.
- 27b. Columbus Co. line; Waccamaw R., approx. 1.6 river km below confluence Juniper Cr., 6 air km SE Old Dock.
28. Columbus Co. line; Waccamaw R., 6.4. air km SE Old Dock, approx. 6.4 river km above NC 130.
- 29a. Columbus Co. line; Waccamaw R., 7.2 air km SE Old Dock, approx. 2.8 river km above NC 130.
- 29b. Columbus Co. line; Waccamaw R., 8 air km SE Old Dock, approx. 1.6 river km above NC 130.
- 29c. Columbus Co. line; Waccamaw R. at NC 130 bridge.
30. Wet Ash Swamp, 5.3 air km NE Longwood on NC 130.
36. Scippee Swamp, 3.2 air km WNW Longwood on CR 1300.

## SOUTH CAROLINA

## HORRY COUNTY (all stations on Waccamaw River)

39. approx. 3.2 air km SE Longs. 0.8 km N to 2.4 km S of SC 9 bridges.
40. 0.8 km S Red Bluff on SC 31.
41. approx. 4.8 river km W Red Bluff.
42. 4.8 air km N Nixonville.
43. 3.2 air km NNW Nixonville.
44. 2.4 air km NW Nixonville at SC 105.
45. 2.4 air km WNW Nixonville.
46. 0.8 air km NW Grahamville.
47. 7.2 air km SE Hickory Grove.
48. 2.4 air km SE Hickory Grove.
49. 5.6 air km W Conway (Hardee's Ferry).
50. 4 air km W Conway.

## ANNOTATED SPECIES LIST

## Lepisosteidae — gars

*Lepisosteus osseus* (Linnaeus), longnose gar. The longnose gar occurs throughout the entire system. Most specimens are from Lake Waccamaw and the main channel of the Waccamaw River. Stations: 1a,c,d,e,f,g, 2b,c, 7, 8a,b,c,d.

## Amiidae — bowfins

*Amia calva* Linnaeus, bowfin. This species appears to be uncommon in Lake Waccamaw, but specimens have been taken throughout the canal system and upper parts of the Waccamaw River. Tightly packed schools of very young bowfin were occasionally observed, and large adults were commonly seen in the river during low water. Stations: 1d, 3, 4, 5, 8a,b,c,d, 9.

## Anguillidae — freshwater eels

*Anguilla rostrata* (Lesueur), American eel. The American eel is common throughout the entire system, in all habitat types sampled where adequate cover exists. Stations: 1a,g,h,i, 2a,c, 7, 8a,b,c,d, 14, 19, 27b, 28, 29a,b,c, 33, 37, 38, 43, 44, 49.

## Clupeidae — herrings

*Alosa pseudoharengus* (Wilson), alewife. Nine juveniles of this anadromous species were collected from a single locality in the main-stream of the river. Station: 42.

*Alosa sapidissima* (Wilson), American shad. Baker (1968) indicated that the American shad ran upstream in the Waccamaw River as far north as Juniper Creek. No specimens were collected during our survey.

*Dorosoma cepedianum* (Lesueur), gizzard shad. All of our collections of this species are from Lake Waccamaw. Most specimens were seined from open shoreline areas at night, but small schools were occasionally encountered while trawling at mid-lake stations. R. H. Moore (pers. comm.) reported gizzard shad from lower sections of the Waccamaw River in South Carolina, Stations: 1a,c,f,i.

*Dorsoma petenense* (Günther), threadfin shad. Threadfin shad were introduced into Lake Waccamaw to provide forage for game species (Nichols 1975). There is no record of successful overwintering and no specimens were taken during our survey.

## Umbridae — mudminnows

*Umbra pygmaea* (DeKay), eastern mudminnow. The mudminnow occurs throughout the system where suitable habitat exists — standing waters with dense growth of aquatic vegetation — and was common in the canals around Lake Waccamaw. Louder (1962a) reported several



specimens collected during a half-acre rotenone sample along the north-east shoreline of the lake. We collected specimens from the lake on one occasion. Stations: 1d, 2b,c, 3, 5, 7, 8d, 9, 12, 21, 24, 25.

#### Esocidae — pikes

*Esox americanus* Gemlin, redbfin pickerel. The redbfin pickerel is common throughout most of the system, except Lake Waccamaw where it was rarely taken. Louder (1962a) reported nine specimens from near the mouth of Second Creek along the northeast shore of the lake. Our only collection from the lake was from an overflow area on the southeastern shore; most of our specimens were taken from standing (often stagnant), weed-choked waters of small streams, canals, and occasionally the main river channel. Stations: 1d, 2a,b,c, 3, 5, 6, 8c,d, 9, 10, 12, 13, 15, 24, 25, 29a,c, 49, 50.

*Esox niger* Lesueur, chain pickerel. This species is also common throughout much of the area surveyed. Frey (1951) and Louder (1962a) reported its presence in the lake. Our only specimen from the lake is a large adult (400-500mm TL) found in a gill net set off the southeastern shore. The main channel of the Waccamaw River and some of its larger tributaries appear to support the best populations of chain pickerel. Stations: 1e, 2a,b,c, 3, 6, 7, 8c,d, 12, 19, 29a,c, 38, 40, 42, 46, 47, 50.

#### Cyprinidae — minnows and carps

*Cyprinus carpio* Linnaeus, carp. Carp are reported by local residents to be abundant in Lake Waccamaw. Indeed, the 1979 annual bow-fishing tournament held at the lake produced 2,860 pounds of carp and longnose gar. Despite these reports, we collected only three carp during our survey and sighted several large adults at one of the canal stations. Louder (1962a) listed this species for the first time from Lake Waccamaw, and (1962b) also reported it from Bogue Swamp and White Marsh Swamp, both tributaries to the Waccamaw River. In addition, R. H. Moore (pers. comm.) reported carp from the lower sections of the river in South Carolina. Stations: 1b,i, 6, 7.

*Hybognathus regius* Girard, eastern silvery minnow. Although the eastern silvery minnow is common in the main channel of Waccamaw River in South Carolina, our survey produced the first specimens from the river in North Carolina. Specimens were collected in open sluggish waters devoid of aquatic vegetation. Stations: 29a, 38, 39, 40, 42, 44, 46.

*Notemigonus crysoleucas* (Mitchill), golden shiner. The golden shiner occurs in a wide variety of habitats throughout the system, but collections usually consist of only a few individuals. It was most often encountered in standing water, and occasionally in the mainstream of the river. Stations: 1a,b,c,e,g,h, 2a,c, 4, 6, 7, 12, 28, 38, 44.

*Notropis chalybaeus* (Cope), ironcolor shiner. Ironcolor shiners occur throughout most of the main channel of the Waccamaw River.

Louder (1962a) reported two specimens from the northeast shore of Lake Waccamaw, and we collected one specimen from the lake. Specimens identified by Fowler (1935) as *Erogala formosa* (Putnam) (= *N. hypselopterus*) from the Waccamaw drainage were determined to be a mixture of *N. chalybaeus* and *N. cummingsae*. *Notropis chalybaeus* was often found in association with *N. petersoni*, although it was never as numerous. Stations: 1g, 7, 19, 28, 29a,c, 39, 49.

*Notropis cummingsae* Myers, dusky shiner. The dusky shiner also appears to be largely confined to the main channel of the river. Small schools were often encountered in open parts of the river, generally those lacking dense vegetation. There are no reports of the species from Lake Waccamaw. Stations: 7, 8a,d, 19, 27a, 28, 29a,c, 50.

*Notropis hudsonius* (Clinton), spottail shiner. Louder (1962b) reported seven specimens of the spottail shiner from Big Creek, the principal feeder stream to Lake Waccamaw. Records also exist from the Waccamaw River in North Carolina (Menhinick, ms.; Gilbert and Burgess 1980). According to Gilbert and Burgess (1980), this species inhabits large, sluggish coastal rivers and brackish waters on the Atlantic slope. The Big Creek locality does not fit this habitat description. The previously mentioned records for *N. hudsonius*, especially Big Creek, may be based on misidentifications. However, museum specimens for these records in the Waccamaw drainage could not be located for examination. During our survey, no spottail shiners were collected.

*Notropis maculatus* (Hay), taillight shiner. This cyprinid is distributed throughout much of the Waccamaw system. Louder (1962b) found it in Bogue Swamp, but it does not appear to be present in Lake Waccamaw. However, one population was located in a canal on the southwest shore of the lake, and another in Big Creek not far from its mouth. Other populations exist in the mainstream of the Waccamaw River. Stations: 2a, 6, 29a, 37, 38.

*Notropis petersoni* Fowler, coastal shiner. This is perhaps the most widespread and abundant cyprinid throughout the system. The Lake Waccamaw population was originally described as *Notropis waccamanus* by Fowler (1942) and later placed in the synonymy of *N. petersoni* by Frey (1951). Davis and Louder (1971) discussed the biology of the species in North Carolina waters (including Lake Waccamaw). We encountered it in all habitat types sampled, with the notable exception of the canals around Lake Waccamaw. Stations: 1,a,b,c,d,e,f,g,h,i,l,m, 2a,c, 7, 8a,b, 19, 27b,c, 31, 37, 38, 39, 40, 42, 44, 47, 49, 50.

#### Catostomidae — suckers

*Erimyzon oblongus* (Mitchill), creek chubsucker. This species is common throughout the system in a wide variety of habitats. Frey (1951) first reported it from Lake Waccamaw, and apparently our single specimen represents the only other published record from the lake. We

encountered difficulties in identifying certain individuals, especially juveniles, which often appear to be intermediate between *E. oblongus* and *E. sucetta*. Rohde et al. (1979) also experienced similar difficulties with specimens from southeastern North Carolina. Hanley (1976) concluded that hybrids between *E. oblongus* and *E. sucetta* do occur, and that these hybrids may backcross with both parental stocks. Stations: 1e, 2a,c, 6, 7, 14, 19, 21, 28, 29c.

*Erimyzon sucetta* (Lacépède), lake chubsucker. Very few lake chubsuckers were taken during our survey and none from Lake Waccamaw, although Louder (1962a) reported four specimens from the northeast shore of the lake. Most of our specimens were taken in heavily vegetated areas of standing or slow-moving water. Stations: 3, 7, 21, 30.

*Minytrema melanops* (Rafinesque), spotted sucker. Our specimens came from the main channel of the Waccamaw River and were taken from open, moving waters with little or no cover. Stations: 19, 38.

#### Ictaluridae — freshwater catfishes

*Ictalurus catus* (Linnaeus), white catfish. The white catfish is widespread throughout Lake Waccamaw and the main channel of the Waccamaw River. Several adults exceeding 400 mm TL were trawled from mid-lake stations. Stations: 1a,b,c,e,h,i, 7, 8a,b,c, 28, 29a, 38, 44, 47.

*Ictalurus melas* (Rafinesque), black bullhead. Louder (1962b) reported the black bullhead from Red Hill Swamp (White Marsh tributary) and Shingletree Swamp (Waccamaw River tributary). We collected no specimens and found no museum specimens, and its occurrence in the Waccamaw drainage is doubtful. Menhinick et al. (1974) suggested that Louder's records probably referred to *I. nebulosus*.

*Ictalurus natalis* (Lesueur), yellow bullhead. No specimens of the yellow bullhead were taken from Lake Waccamaw during our survey, but several were collected from the main channel of the Waccamaw River. Louder (1962a) reported one small specimen from the northeast shore of the lake. Stations: 8a,b,d, 19, 29a,47.

*Ictalurus nebulosus* (Lesueur), brown bullhead. The brown bullhead has not previously been reported from Lake Waccamaw, but we collected four specimens there during our survey. E. F. Menhinick (pers. comm.) collected two specimens from Toms Fork Creek, a tributary to Seven Creeks. Stations: 1b,h.

*Ictalurus platycephalus* (Girard), flat bullhead. We discovered one adult flat bullhead in a gill net set off the southeastern shore of Lake Waccamaw, which represents only the second published report of this species from the lake. Louder (1962a) reported a specimen from along the northeast shore of the lake. The species is also present in the Waccamaw River below Conway, South Carolina (R. H. Moore, pers. comm.). Station: 1e.

*Ictalurus punctatus* (Rafinesque), channel catfish. Although no specimens of the channel catfish were collected during our survey, R. H. Moore (pers. comm.) reported its presence in the lower reaches of the Waccamaw River.

*Noturus gyrinus* (Mitchill), tadpole madtom. The tadpole madtom has been taken in a variety of habitats throughout much of the system. Most of our specimens came from the lake and the main channel of the Waccamaw River. This madtom generally avoids swifter sections of the river and was usually associated with thick vegetation or debris. Frey (1951) discussed variation between populations from the North Carolina Bay Lakes (including Lake Waccamaw). Stations: 1a,c,e,f,g,h,i, 2c, 5, 7, 8a, 38, 40, 46.

*Noturus insignis* (Richardson), margined madtom. This species was taken exclusively from areas of flowing water and abundant cover in the main channel of the Waccamaw River. It appeared to be the dominant ictalurid species captured in the river. Stations: 7, 8a,d, 19, 28, 29a,b, 38.

*Noturus* species, broadtail madtom. Two distinct populations of this undescribed madtom exist in the Waccamaw drainage. The form found in the main channel of the Waccamaw River, taken by us from Station 19 and downstream sites, is also found in the adjacent Cape Fear drainage (Jenkins and Palmer 1978). It often occurred with *N. insignis*. Specimens from Lake Waccamaw clearly differ from the river specimens, but the degree of differentiation has not yet been determined (R. E. Jenkins, pers. comm.). The closest relative appears to be *N. leptacanthus* (Jenkins and Palmer 1978). The Lake Waccamaw form (found throughout the lake and directly below the dam) was often found in cans and bottles as well as under tiles placed as experimental spawning sites for the Waccamaw darter. Broadtail madtoms appear to be relatively common in the lake and may outnumber *N. gyrinus*. Stations: 1a,c,d,f,i,j,k,l,m, 7, 19, 28, 29a, 38, 50.

#### Amblyopsidae — cavefishes

*Chologaster cornuta* Agassiz, swampfish. The swampfish was never common at any locality. It was encountered in standing or sluggish waters, usually choked with aquatic vegetation or debris. No record of this species from Lake Waccamaw exists and we found none there during our survey. Stations: 2b,c, 6, 7, 8a,b,c,d, 24, 25, 26.

#### Aphredoderidae — pirate perches

*Aphredoderus sayanus* (Gilliams), pirate perch. Although Louder (1962a) reported the pirate perch from Lake Waccamaw, and E. F. Menhinick (pers. comm.) also collected one lake specimen, we collected none from the lake. Pirate perch do occur in standing or sluggish and

heavily vegetated waters elsewhere throughout the system. Stations: 2a,b,c, 3, 4, 6, 7, 8a,b,c,d, 10, 12, 13, 15, 17, 19, 20, 21, 22, 24, 25, 26, 27a, 29b,c, 30, 38, 39, 43.

#### Cyprinodontidae — killifishes

*Fundulus chrysotus* (Günther), golden topminnow. The range of the golden topminnow was originally thought to extend along the Atlantic coast only as far north as the Santee drainage, South Carolina (Shute 1980). Recently, however, specimens were collected by R. H. Moore (pers. comm.) from the Waccamaw River at Bucksville, South Carolina, 12.5 air km south-southeast of Conway. We examined the specimens and concur with Moore's identification. In addition, specimens from Waverly Mills, South Carolina (Waccamaw drainage) identified as this species by Fowler (1935) have been verified.

This species prefers river backwaters, slow-moving streams, or ditches, and is usually associated with dense growths of aquatic vegetation (Shute 1980). Ample habitat certainly exists throughout most of the drainage and additional populations quite likely exist.

*Fundulus diaphanus* (Lesueur), banded killifish. Fowler (1935) reported the banded killifish from Waverly Mills (presumably on the Waccamaw River), South Carolina. These specimens were examined by Hubbs and Raney (1946) and re-examined by us, and are typically *F. diaphanus*. This represents the southernmost extent of the species' range (Gilbert and Shute 1980). No banded killifish were collected during our survey.

*Fundulus lineolatus* (Agassiz), lined topminnow. We collected this species from Lake Waccamaw for the first time. The species is rare in the lake but common throughout the swamps and canals of the system. Specimens are usually encountered in standing, heavily-vegetated, dark-stained waters. Stations: 1c,g,h, 2a,b,c, 3, 6, 7, 13, 14, 17, 20, 21, 22, 24, 27a, 28, 29c, 30, 37, 38, 40.

*Fundulus waccamensis* Hubbs and Raney, Waccamaw killifish. The Waccamaw killifish was originally described as a Lake Waccamaw endemic by Hubbs and Raney (1946). Recently, however, Bailey (1977) reported specimens believed to be *F. waccamensis* from Lake Phelps, most of which lies in Washington County in northeastern North Carolina. Specimens from Lake Phelps examined by us and E. F. Menhinick (pers. comm.) were found to differ slightly from *F. waccamensis* in respect to head length, interorbital width, and caudal peduncle length. This slight differentiation might tend to lessen the possibility that *F. waccamensis* was accidentally introduced into Lake Phelps.

In the Waccamaw system, this killifish occurred at nearly all lake stations sampled. In addition, it was found (especially during winter months) throughout the lower parts of Big Creek, the canals around the

lake, and in the headwaters of the river just below the dam. The Waccamaw killifish typically inhabits the shallow, sandy shoreline of the lake where it is often associated with dense stands of *Panicum hemitimum*. No specimens have been taken in the river farther than 100 m below the lake. Stations: 1a,b,c,d,e,f,g,h,i,l, 2a,b,c, 3, 4, 5, 6, 7.

#### Poeciliidae — livebearers

*Gambusia affinis* (Baird and Girard), mosquitofish. The mosquitofish was collected throughout the entire system in nearly every habitat type sampled, but was never collected while trawling at mid-lake stations and was only rarely taken at other stations within the lake. Stations. 1a,b,c,d,e,f,g,h, 2a,b,c, 3, 4, 5, 6, 7, 8a,b,c,d, 9, 10, 12, 14, 19, 20, 21, 22, 27a,b, 28, 29a,b,c, 30, 31, 33, 34, 36, 37, 38, 39, 40, 42, 43, 44, 49, 50.

*Heterandria formosa* Agassiz, least killifish. This diminutive poeciliid was only collected from one station in the South Carolina section of the Waccamaw River, and is probably more abundant in the extreme lower reaches of the river. Fowler (1935) reported it from Waverly Mills, South Carolina (Waccamaw drainage). Station: 42.

#### Atherinidae — silversides

*Menidia extensa* Hubbs and Raney, Waccamaw silverside. The Waccamaw silverside is possibly the most abundant fish in Lake Waccamaw. It also has the most limited distribution of the described endemic species in the lake. Specimens have never been collected in Big Creek or the canals surrounding the lake. A few stragglers (washovers) are occasionally taken below the dam, but never more than 30 or 40 m downstream from the lake. This species inhabits open, non-vegetated waters along the shoreline of the lake and is occasionally taken in offshore waters. Stations: 1a,b,c,d,e,f,g,h,i, 7.

#### Percichthyidae — temperate basses

*Morone americana* (Gmelin), white perch. The white perch is common in Lake Waccamaw and is considered to be the predominant game species there. It was encountered, often in large numbers, at mid-lake trawl stations. Except for one adult from Big Creek and another from below the dam, the species was not collected outside the lake during our survey. The specimen from Big Creek was injured and may have been released by a fisherman. R. H. Moore (pers. comm.) reported white perch from the lower Waccamaw River and Winyah Bay in South Carolina. Stations: 1a,b,c,e,f,g,i, 2a, 7.

*Morone saxatilis* (Walbaum), striped bass. Baker (1968) indicated that this anadromous species runs up the main channel of the Waccamaw River almost as far north as Juniper Creek. No specimens were collected during our survey.

## Centrarchidae — sunfishes

*Acantharchus pomotis* (Baird), mud sunfish. This secretive species was rarely encountered during our survey and was never collected from Lake Waccamaw. Louder (1962a) reported it from a rotenone station along the northeast shore of the lake, an area where feeder streams enter and aquatic vegetation is abundant. We usually found it in areas of standing water where submergent vegetation was extremely dense. Stations: 2b, 3, 8d, 9, 13, 15.

*Centrarchus macropterus* (Lacépède), flier. Louder (1962a) reported the flier from Lake Waccamaw. Bruce B. Collette (pers. comm.) also collected an adult from the north shore of Lake Waccamaw in 1958. We collected no specimens from the lake, but found the species throughout much of the rest of the drainage, where it preferred standing or sluggish water, usually with an abundance of aquatic vegetation. Stations: 2b,c, 4, 5, 6, 9, 10, 12, 28, 34, 38, 43.

*Elassoma evergladei* Jordan, Everglades pygmy sunfish. Three specimens of the Everglades pygmy sunfish, the first to be reported from Lake Waccamaw, were collected from a swampy area on the southeastern shore of the lake. Major populations appear to be confined mainly to Juniper Creek and tributaries where it is often associated with an undescribed pygmy sunfish. Specimens were usually collected from weedy, shallow backwaters of small streams. Stations: 1d, 17, 21, 23, 24, 25, 26, 30.

*Elassoma zonatum* Jordan, banded pygmy sunfish. Louder (1962a) reported this pygmy sunfish from Lake Waccamaw, where it was collected with rotenone from dense vegetation along the northeast shore. We did not find it in the lake, but specimens were commonly taken from the surrounding canals and Big Creek. The species is common throughout the system, except where replaced by *E. evergladei* and the undescribed form. The habitat is similar to that of *E. evergladei*. Stations: 2a,b, 3, 4, 5, 6, 7, 8a,b,c,d, 9, 10, 12, 13, 15, 19, 20, 22, 27b, 29c, 30, 33, 34, 38.

*Elassoma* species, undescribed pygmy sunfish. This species, closely related to *E. zonatum* (Böhlke and Rohde 1980), has only been collected from two streams in the Waccamaw drainage. It is relatively common throughout Juniper Creek, where its distribution and habitat closely parallel those of *E. evergladei*. It is also collected regularly from one Big Creek tributary (Station 2b), and has been taken once in the main channel of Big Creek (Station 2c) and once at Station 2a. The absence of this species from other streams within the system suggests a limited distribution. Olmsted and Cloutman (1978) reported collecting an undescribed *Elassoma* species from Black Creek (Pee Dee drainage) in the Sandhills National Wildlife Refuge, South Carolina, but this report appears to be based on misidentified *E. zonatum* (F. C. Rohde, pers. comm.). Pygmy sunfish superficially resembling this species have been

collected by Rohde (pers. comm.) from Jasper County, South Carolina (Savannah drainage). In addition to stations listed below, three specimens were recently collected from a canal just east of Lake Waccamaw (not mapped). Stations: 2a,b,c, 21, 24, 25, 26.

*Enneacanthus chaetodon* (Baird), blackbanded sunfish. This centrarchid was collected from only six localities throughout the system, where it occurs in standing, heavily vegetated waters. Aquatic pondweed, *Potamogeton* sp., was often present where specimens were collected. Stations: 2a,b,c, 6, 8d, 21.

*Enneacanthus gloriosus* (Holbrook), bluespotted sunfish. The bluespotted sunfish is distributed throughout the entire system but was collected only once from Lake Waccamaw during our survey. It occurs in quiet weedy backwaters of the Waccamaw River and tributaries. Stations: 1d, 2a,b,c, 3, 4, 5, 6, 7, 10, 16, 21, 23, 24, 26, 29c, 38.

*Enneacanthus obesus* (Girard), banded sunfish. Louder (1962a) reported this small species from Lake Waccamaw, and we collected it there once. It was collected at scattered localities throughout the system, and many specimens came from the Juniper Creek area. Habitat preferences are similar to those of the other *Enneacanthus* species. Stations: 1d, 2a,b,c, 3, 8, 17, 21, 23, 26, 30.

*Lepomis auritis* (Linnaeus), redbreast sunfish. Major populations of this sunfish appear to be confined to the Waccamaw River; few specimens were collected from Lake Waccamaw, and only two individuals were taken from Big Creek. The redbreast sunfish was stocked in Lake Waccamaw by the North Carolina Wildlife Resources Commission (Nichols 1975). Stations: 1,g,j, 2a, 7, 8a, 19, 27a, 28, 29a,b, 31, 37, 38, 39, 40, 42, 44, 49, 50.

*Lepomis gibbosus* (Linnaeus), pumpkinseed. The pumpkinseed was commonly collected from Lake Waccamaw and the main channel of the Waccamaw River, but was clearly absent from most of the smaller tributaries. Adult specimens were often trawled from open waters of the lake. Stations: 1a,d,g,h,i, 2a,b,c, 3, 4, 7, 8a,d, 21, 29c, 37.

*Lepomis gulosus* (Cuvier), warmouth. Although both Louder (1962a) and Frey (1951) reported this species in Lake Waccamaw, we took none from the lake during our survey. The species was common in Big Creek, the canals around Lake Waccamaw, and many Waccamaw River tributaries, where it occurs in quiet, weedy streams and river backwaters. Stations: 2a,b,c, 4, 6, 7, 12, 14, 20, 21, 38, 40.

*Lepomis macrochirus* Rafinesque, bluegill. Bluegills are common throughout the entire Waccamaw system, including Lake Waccamaw. Specimens were associated with some type of cover, usually aquatic vegetation or cypress stumps. Despite its abundance, large adults were rarely taken. Stations: 1a,b,c,e,g,h,i, 2a,b,c, 3, 4, 6, 7, 8a,b,c, 12, 14, 21, 24, 29a,c, 31, 33, 34, 37, 38, 39, 40, 44, 49, 50.



*Lepomis marginatus* (Holbrook), dollar sunfish. Two adult specimens, taken on separate occasions, were collected from the south shore of Lake Waccamaw above the dam. This is the first report of the species from the lake. Throughout the system the dollar sunfish has been collected in shallow, weedy backwaters of the river and tributaries, as well as in borrow pits in the Green Swamp. Stations: 1g, 2a,c, 7, 8b,c, 19, 21, 27b, 29a, c, 37, 38, 39, 40.

*Lepomis microlophus* (Günther), redear sunfish. The redear sunfish was introduced into the Waccamaw drainage to establish another suitable game species (Louder 1962b; Nichols 1975, and pers. comm.). During our survey no specimens were collected from Lake Waccamaw and only one was collected from the Waccamaw River in south Carolina. Louder (1962b) reported specimens from Big Creek, Gum and Grey swamps (White Marsh tributaries), Tabor City Run (Seven Creeks tributary), and South Ash Swamp (direct tributary to Waccamaw River). Station: 42.

*Lepomis punctatus* (Valenciennes), spotted sunfish. Frey (1951) first reported the spotted sunfish in Lake Waccamaw. We failed to collect any from the lake during our survey and took specimens only from two localities on the Waccamaw River. Louder (1962b) reported the species present throughout much of the system, and included several specimens from Big Creek. Preferred habitat appears to be quiet, vegetated backwaters. Stations: 38, 40.

*Micropterus salmoides* (Lacépède), largemouth bass. Largemouth bass are common throughout Lake Waccamaw and much of the Waccamaw River. Outside the lake the species appeared to be most common in the main channel of the river and its larger tributaries. Stations: 1a,c,d,e,g,h,l,k, 2a,c, 6, 7, 8a,b, 14, 29a, 37, 38, 39, 49, 42.

*Pomoxis nigromaculatus* (Lesueur), black crappie. Although Louder (1962a) reported this species to be one of the most important game fishes in Lake Waccamaw, it was not often collected during our survey. The species has been found in habitats ranging from open lake waters to flood ponds of small swamps. Stations: 1a,e,i, 7, 12, 44.

#### Percidae — perches

*Etheostoma fusiforme* (Girard), swamp darter. The swamp darter is the most widespread percid in the Waccamaw system, occurring in nearly every habitat type sampled. It is particularly abundant in the offshore waters of Lake Waccamaw. The northern subspecies, *Etheostoma fusiforme fusiforme* (Girard) reaches its southernmost limit in the Waccamaw River (Collette 1962), but is replaced by the southern species, *E. f. barratti* (Holbrook), in the Pee Dee River (of which the Waccamaw is a tributary). All of our specimens were the nominate subspecies, but extensive studies have not been conducted. Bailey and Frey

(1951) studied variation in darters of the subgenus *Hololepis* from some natural lakes of North Carolina (including Lake Waccamaw). Stations: 1a,b,c,d,e,f,g,h,i,m, 2a,c, 3, 4, 6, 7, 14, 21, 22, 27b, 28, 29c, 33, 37, 39, 44, 49.

*Etheostoma olmstedi* Storer, tessellated darter. With very few exceptions, this darter is confined to the main channel of the Waccamaw River. Few other streams in the system offer suitable habitat, which most often was shallow, moving water over sand or fine gravel substrate. Stations: 7, 8a,b,c,d, 19, 27a,b, 28, 29a,b,c, 31, 33, 38, 39, 40, 41, 42, 43, 44, 47, 49.

*Etheostoma perlongum* (Hubbs and Raney), Waccamaw darter. We collected the Waccamaw darter from all localities sampled within Lake Waccamaw. In spring and summer months it is common along the shallow shoreline of the lake, sometimes in association with emergent vegetation, but during colder months specimens are more often collected in offshore waters. *Etheostoma perlongum* is sometimes taken below the dam and in the upper headwaters of the Waccamaw River, where it is found in association with *E. olmstedi* and where specimens exhibiting characters intermediate between the species are often collected. Stations: 1a,b,c,d,e,f,g,h,i,j,k,l,m, 7,8a.

*Etheostoma serriferum* (Hubbs and Cannon), sawcheek darter. The sawcheek darter is widely distributed throughout the system, but no specimens were collected from Lake Waccamaw. The species prefers standing or sluggish and heavily vegetated water, often rich in organic debris, and often occurs in the same habitat as pygmy sunfishes. Stations: 2b, 4, 6, 7, 8d, 13, 19, 21, 22, 24, 26, 27a, 28, 29a,c, 30, 33, 37, 38, 40, 42, 43, 44.

*Perca flavescens* (Mitchill), yellow perch. The yellow perch is common in Lake Waccamaw and occasionally was collected in the Waccamaw River. It occurs in open waters with little cover, and is taken by anglers, especially from areas around the dam. Stations: 1a,b,e,f,g,i,k,l,m, 2a, 7, 8d, 38, 42.

#### Soleidae — soles

*Trinectes maculatus* (Bloch and Schneider), hogchoker. We collected the hogchoker only from the lower reaches of the Waccamaw River, where specimens were taken in quiet, sluggish open waters over mud bottoms. Stations: 40, 44, 48, 49, 50.

### DISCUSSION

A drainage is defined by Jenkins et al. (1972) as "an interconnected major group of streams, or systems entering the marine habitat. . . ." Geographically, the Waccamaw River is a tributary in the Pee Dee drainage, and the Waccamaw and Pee Dee rivers converge to form the upper part of Winyah Bay, an estuarine habitat. We propose that

Winyah Bay forms an effective barrier limiting faunal exchange between the two rivers, at least for most of the freshwater forms. Therefore, we argue that the Waccamaw should be viewed as a separate drainage that limits dispersal of most primary freshwater fishes. A similar situation exists between the Chowan and Roanoke Rivers, where the Chowan enters the Roanoke drainage in the estuarine habitat of Albemarle Sound. According to Jenkins et al. (1972) there is "some merit in considering it (the Chowan) a separate drainage."

Fifty-six species of freshwater and diadromous fishes were collected from the Waccamaw drainage during our survey. These include four families of secondary freshwater fishes (Lepisosteidae, Cyprinodontidae, Poeciliidae and Atherinidae), and four families of diadromous fishes (Anguillidae, Clupeidae, Percichthyidae, and Soleidae), with the remaining ten families representing primary freshwater forms (mostly after Myers 1938). Most of the secondary freshwater and diadromous species behave as primary forms, and two — *Fundulus waccamensis* and *Menidia extensa* — are known only from fresh water. Nine additional species—*Alosa sapidissima*, *Dorosoma petenense*, *Notropis hudsonius*, *N. hypselopterus*, *Ictalurus melas*, *I. punctatus*, *Fundulus chrysotus*, *F. diaphanus* and *Morone saxatilis* — have been reported (various sources listed in text) from the Waccamaw River and tributaries. Of these, *Fundulus chrysotus* and *F. diaphanus* have been examined and verified by us. *Alosa sapidissima*, *Notropis hudsonius*, *Ictalurus punctatus* and *Morone saxatilis* were not verified, but probably do occur. It is doubtful that the remaining three species — *Dorosoma petenense*, *Notropis hypselopterus*, and *Ictalurus melas* — are found in this drainage. Compared to other small Atlantic Coastal Plain drainages, the Waccamaw drainage has an unusually high species diversity (Table 2). This can be partly attributed to the lentic habitats of Lake Waccamaw, from which 44 species have been collected by us or otherwise reported.

The Waccamaw and Little Pee Dee (Big Swamp and Lumber systems) once occupied a much larger basin draining areas of the inner Coastal Plain and Piedmont. Approximately 75,000 years ago the uplift of the Cape Fear Fault (roughly paralleling the Cape Fear River) resulted in elevation of land southwest of the Cape Fear River and subsequent pirating of the upper parts of the Waccamaw and Little Pee Dee systems by the Cape Fear (Zullo and Harris 1979). Stream flow was diverted along this fault to form the Cape Fear River, leaving the Waccamaw and Little Pee Dee systems with greatly reduced drainage basins confined largely to the Coastal Plain. Zoogeographic evidence also suggests a close relationship between these drainages. Three species of fish are shared exclusively by the Cape Fear and Pee Dee drainages: *Semotilus lumbee*, Sandhills chub (Snelson 1980); *Hybopsis* species, thinlip chub (Jenkins and Lachner 1980); and *Noturus* species, broadtail madtom (Jenkins and Palmer 1978). However, only one of these, the broad-

Table 2. Number of species (genera) found in fresh waters of selected Atlantic coastal drainages.

Family	Waccamaw <sup>1</sup>	Shallotte <sup>2</sup>	White Oak <sup>3</sup>	Newport <sup>3</sup>	South Carolina <sup>4</sup>
Lepisosteidae	1(1)	1(1)	1(1)	1(1)	-
Amiidae	1(1)	-	-	-	1(1)
Anguillidae	1(1)	1(1)	1(1)	1(1)	1(1)
Clupeidae	2(2)	-	1(1)	1(1)	-
Umbridae	1(1)	1(1)	1(1)	1(1)	1(1)
Esocidae	2(1)	2(1)	2(1)	2(1)	2(1)
Cyprinidae	7(4)	5(3)	3(2)	3(3)	7(2)
Catostomidae	3(2)	1(1)	3(2)	2(1)	3(2)
Ictaluridae	7(2)	3(2)	5(2)	5(2)	6(2)
Amblyopsidae	1(1)	-	1(1)	1(1)	1(1)
Aphredoderidae	1(1)	1(1)	1(1)	1(1)	1(1)
Cyprinodontidae	4(1)	1(1)	-	-	2(1)
Poeciliidae	2(2)	1(1)	1(1)	1(1)	3(3)
Atherinidae	1(1)	-	-	-	1(1)
Percichthyidae	1(1)	-	-	-	-
Centrarchidae	17(7)	12(7)	10(5)	10(6)	16(7)
Percidae	5(2)	3(1)	4(2)	4(2)	5(2)
Soleidae	1(1)	-	1(1)	1(1)	1(1)
TOTALS	58(32)	32(21)	35(22)	34(23)	51(27)

1. Only species collected or verified by us during present survey.
2. Data from Louder (1962b). Only specimens listed from fresh water.
3. Data from Rohde et al. (1979). *Eucinostomus argenteus*, *Lagodon rhomboides*, and *Dormitator maculatus* not included.
4. Combined Ashepoo, Combahee, Broad, and New rivers. Data modified from Swift et al. (1977) with additional species from Anderson (1964); record of *Chaetodipterus faber* not included.

tail madtom, is known from the Waccamaw. The remaining two species are known from the Lumber and Lynches rivers of the Pee Dee drainage. Therefore, it is not surprising that much of the ichthyofauna of the lower Pee Dee (Waccamaw, Lumber and Big Swamp systems) is shared with the Cape Fear drainage (Average Faunal Resemblance Index = 84; Jenkins et al. 1972). Indeed, only two other rivers of the Central Atlantic Slope (Neuse and Tar) show a greater degree of faunal resemblance (Average Faunal Resemblance Index = 94; Jenkins et al. 1972).

Additionally, *Etheostoma fusiforme fusiforme* reaches the southern terminus of its range in the Waccamaw River (Collette 1962). *Etheostoma f. barratti* is found from the Pee Dee drainage (to which the Waccamaw is an eastern tributary) southward. The presence of *E. f. fusiforme* in both the Waccamaw and Cape Fear rivers and its absence

from the Pee Dee provides further evidence of past connections between the two drainages and suggests a faunal separation of the Waccamaw from the Pee Dee. We suggest that populations of *E. f. fusiforme* were probably present in the Little Pee Dee system (as in the Cape Fear and Waccamaw) before the uplift of the Cape Fear Fault. *Etheostoma f. barratti* from the Pee Dee then invaded the Lumber via the Little Pee Dee, replacing the nominate subspecies. There was possibly little or no opportunity for such upstream dispersal of *E. f. barratti* into the Waccamaw because of salinity barriers, and therefore the populations of *E. f. fusiforme* persisted.

Only one known connection between the Waccamaw and Cape Fear rivers presently exists. A series of man-made canals, dug to improve tree farm drainage, connects Honey Island Swamp (Juniper Creek tributary) with Dans Creek of the Cape Fear drainage and Big absence Creek which drains into Lake Waccamaw (Fig. 1). Only a limited number of species should be able to negotiate the small, shallow and often stagnant canals, thus limiting substantial faunal exchange. The undescribed *Elassoma* was recently collected in one of these canals just east of Lake Waccamaw, which suggests the possibility that it may have gained access to the Big Creek system via the canals from Juniper Creek. This may explain of the species from areas west of the Waccamaw River and other tributaries of the river (apart from Juniper Creek and Big Creek) even where habitat appears suitable. Northward expansion of its range would be possible through the canal system into the Cape Fear drainage. Collecting in adjacent Cape Fear drainages has, however, provided no specimens.

According to Jenkins et al. (1972), lowland endemics or exclusively shared forms are not common on the Central Atlantic Slope. The Waccamaw has at least five of these. *Etheostoma perlongum* and *Menidia extensa* are Waccamaw endemics. *Fundulus waccamensis* is either endemic to the Waccamaw or shared with Lake Phelps (coastal Albemarle drainage), pending taxonomic decisions. The undescribed *Elassoma* is probably shared between the Waccamaw and Savannah drainages (F. C. Rohde, pers. comm.). The undescribed *Noturus* is represented by two forms within the Waccamaw drainage; specimens from Lake Waccamaw represent a population superficially distinct from the Waccamaw River population and may represent another Waccamaw endemic. The form present in the Waccamaw River is also found in rivers of the lower Pee Dee and Cape Fear drainage (Jenkins and Palmer 1978; Jenkins, pers. comm.).

In summary, the Waccamaw drainage is unique among small central Atlantic coastal drainages in having a highly diversified fish fauna including endemic and exclusively shared forms. The Waccamaw and Little Pee Dee systems once extended farther north into the inner Coastal Plain and Piedmont. These streams were beheaded by the uplifting of

the Cape Fear Fault and subsequent formation of the Cape Fear River, resulting in faunal similarities between the drainages.

*ACKNOWLEDGMENTS.*— This study was made possible by grant-in-aid funds under Section 6 of the Endangered Species Act of 1973 (PL 93-205). We wish to thank Edward F. Menhinick, University of North Carolina at Charlotte, for his assistance in locating questionable records and permission to review his unpublished distribution maps of North Carolina freshwater fishes. William M. Palmer and Alvin L. Braswell provided access to state stream survey collections housed at the North Carolina State Museum of Natural History. Joseph R. Bailey, Duke University, provided information on specimens in his care. Peter S. Coleman, Charleston Museum, was extremely helpful in locating and verifying specimens housed in his care. We are grateful to Richard H. Moore, Coastal Carolina College, for supplying us with information and specimens from the Waccamaw River in South Carolina. In addition, we would like to thank all those who assisted in many hours of field work during this survey. Dr. Bruce B. Collette, National Marine Fisheries Service, provided helpful comments on the manuscript, and copies of some of his field notes from Waccamaw studies. Fred C. Rohde and Robert E. Jenkins also reviewed the manuscript. Finally, we thank John A. McNeill, Sr., for use of his cabin at Lake Waccamaw.

#### LITERATURE CITED

- Anderson, William D. 1964. Fishes of some South Carolina Coastal Plain streams. *J. Fla. Acad. Sci.* 27(1):31-54.
- Anonymous. 1978. Preliminary analysis of the potentials of the Waccamaw River for inclusion into the North Carolina Natural and Scenic Rivers Systems. Compiled by Natural and Scenic Rivers study team, Columbus Co., North Carolina. Unpublished.
- Bailey, Joseph R. 1977. Freshwater Fishes. pp. 265-298 in J. E. Cooper, S. S. Robinson and J. B. Funderburg (eds.). *Endangered and Threatened Plants and Animals of North Carolina*. N. C. State Mus. Nat. Hist., Raleigh. xvi + 444 pp.
- , and D. G. Frey. 1951. Darters of the genus *Holelepis* from some natural lakes of North Carolina. *J. Elisha Mitchell Sci. Soc.* 67(2):191-204.
- Baker, W. Donald. 1968. A reconnaissance of anadromous fish runs into the inland fishing waters of North Carolina. *Fed. Aid Fish Restor. Proj. AFS-3*, N. C. Wildl. Resour. Com., Raleigh. 23 pp.
- Böhlke, James E., and F. C. Rohde. 1980. *Elassoma zonatum* Jordan, banded pygmy sunfish. p. 586 in D. S. Lee, et al. *Atlas of North American Freshwater Fishes*, N.C. State Mus. Nat. Hist., Raleigh. x + 867 pp.
- Collette, Bruce B. 1962. The swamp darters of the subgenus *Holelepis* (Pisces, Percidae). *Tulane Stud. Zool.* 9(4):115-211.
- Davis, James R., and D. E. Louder. 1969. Life history and ecology of *Menidia extensa*. *Trans. Am. Fish. Soc.* 98(3):466-472.

- \_\_\_\_\_, and \_\_\_\_\_. 1971. Life history and ecology of the cyprinid fish *Notropis petersoni* in North Carolina waters. *Trans. Am. Fish Soc.* 100(4):726-733.
- Fowler, Henry W. 1935. Notes on South Carolina freshwater fishes. *Contrib. Charleston Mus.* 7. 28pp.
- \_\_\_\_\_. 1942. Description of six new freshwater fishes (Cyprinidae and Percidae) from the southeastern United States. *Not. Nat. (Phila.)* 107. 11 pp.
- Frey, David G. 1948a. North Carolina's bay lakes. *Wildl. in N. C.* 12(9):3-8.
- \_\_\_\_\_. 1948b. A biological survey of Lake Waccamaw. *Wildl. in N. C.* 12(9):17-20.
- \_\_\_\_\_. 1949. Morphometry and hydrography of some natural lakes of the North Carolina Coastal Plain. The bay lake as a morphometric type. *J. Elisha Mitchell Sci. Soc.* 65(1):1-37.
- \_\_\_\_\_. 1951. The fishes of North Carolina's bay lakes and their intraspecific variation. *J. Elisha Mitchell Sci. Soc.* 67(1):1-44.
- Gilbert, Carter R., and G. H. Burgess. 1980. *Notropis hudsonius* (Clinton), spottail shiner. pp. 275-76 in D. S. Lee, et al. *Atlas of North American Freshwater Fishes*. N. C. State Mus. Nat Hist., Raleigh. x + 867 pp.
- \_\_\_\_\_, and J. R. Shute. 1980. *Fundulus diaphanus* (Lesueur), banded killifish. p. 513 in D. S. Lee, et al. *Atlas of North American Freshwater Fishes*. N. C. State Mus. Nat. History., Raleigh. x + 867 pp.
- Hanley, Robert W. 1976. Population phenetics of chubsuckers in North Carolina (*Erimyzon*: Catostomidae). Unpub. Master's thesis, Duke Univ., Durham. 182 pp.
- Hubbs, Carl L., and E. C. Raney. 1946. Endemic fish fauna of Lake Waccamaw, North Carolina. *Misc. Publ. Univ. Mich. Mus. Zool.* 65:1-30.
- Hueske, Edward E. 1948. Fish resources of the bay lakes. *Wildl. in N. C.* 12(9):11-16.
- Jenkins, Robert E., and E. A. Lachner. 1980. *Hybopsis zanema* (Jordan and Brayton), Santee chub. p. 197 in D. S. Lee, et al. *Atlas of North American Freshwater Fishes*. N. C. State Mus. Nat Hist., Raleigh. x + 867 pp.
- \_\_\_\_\_, \_\_\_\_\_ and F. J. Schwartz. 1972. Fishes of the central Appalachian drainages: their distribution and dispersal. pp. 43-117 in P. C. Holt (ed.). *The distributional history of the biota of the southern Appalachians*, Part III: Vertebrates. *Res. Div. Monogr.* 4, Va. Polytech. Inst. State Univ., Blacksburg. 306 pp.
- \_\_\_\_\_, and W. M. Palmer. 1978. A new species of madtom catfish (Ictaluridae) from the Coastal Plain of the Carolinas. *ASB Bull.* 25(2):57. Abstract.
- Lindquist, David G., J. R. Shute and P. W. Shute. 1981. Spawning and nesting behavior of the Waccamaw darter, *Etheostoma perlongum*. *Environ. Biol. Fishes* 6(2):177-191.
- Louder, Darrell E. 1962a. An annotated checklist of the North Carolina bay lakes fishes. *J. Elisha Mitchell Sci. Soc.* 78(1):68-73.
- \_\_\_\_\_. 1962b. Survey and classification of the Lumber River and Shallotte River, North Carolina. *Final Rep. Fed. Aid Fish Restor. Proj. F-14-R*, N. C. Wildl. Resour. Com., Raleigh. 12 pp.

- Menhinick, Edward F. Manuscript. The Freshwater Fishes of North Carolina.
- \_\_\_\_\_, T. M. Burton and J. R. Bailey. 1974. An annotated checklist of the freshwater fishes of North Carolina. *J. Elisha Mitchell Sci. Soc.* 90(1):24-50.
- Myers, George S. 1938. Fresh-water fishes and west Indian zoogeography. *Smithson. Inst. Annu. Rep.* (1937), Publ. 3465:339-64.
- Nichols, Lacy E. 1975. Lake Waccamaw. *N. C. Wildl. Resour. Com.*:1-8.
- Olmsted, Larry L., and D. G. Cloutman. 1978. Fishes of the Carolina Sandhills National Wildlife Refuge. Final Rep. U. S. Dept. Inter., Fish Wildl. Serv., Carolina Sandhills Nat. Wildl. Refuge, McBee, SC. 26 pp.
- Robins, C. Richard, R. M. Bailey, C. E. Bond, J. R. Brooker, E. A. Lachner, R. N. Lea and W. B. Scott. 1980. A List of Common and Scientific Names of Fishes from the United States and Canada (4th ed.). *Am. Fish. Soc. Spec. Publ.* 12. 174 pp.
- Rohde, Fred C., G. H. Burgess and G. W. Link. 1979. Freshwater fishes of Croatan National Forest, North Carolina, with comments on the zoogeography of Coastal Plain fishes. *Brimleyana* 2:97-118.
- Shute, John R. 1980. *Fundulus chrysotus* (Günther), golden topminnow. p. 510 in D. S. Lee, et al. Atlas of North American Freshwater Fishes. N. C. State Mus. Nat. Hist., Raleigh. x + 867 pp.
- Shute, Peggy W., D. G. Lindquist and J. R. Shute. Manuscript. Spawning behavior, reproduction, fecundity, sexual dimorphism and early life history stages of the Waccamaw killfish, *Fundulus waccamensis*. Submitted to *Environ. Biol. Fishes*.
- \_\_\_\_\_, J. R. Shute and D. G. Lindquist. 1979. Notes on the Spawning, fecundity and diet of the Waccamaw killfish, *Fundulus waccamensis*. *ASB Bull.* 26(2):49. Abstract.
- \_\_\_\_\_, \_\_\_\_\_ and \_\_\_\_\_. In press. Age, growth and early life history of the Waccamaw darter, *Etheostoma perlongum*. *Copeia*.
- Snelson, Franklin F., Jr. 1980. *Semotilus lumbee* Snelson and Suttkus, Sandhills Chub. p. 363 in D. S. Lee, et al. Atlas of North American Freshwater Fishes. N. C. State Mus. Nat. Hist., Raleigh x + 867 pp.
- Swift, Camm, R. W. Yerger and P. R. Parrish. 1977. Distribution and natural history of the fresh and brackish water fishes of the Ochlockonee River, Florida and Georgia. *Bull. Tall Timbers Res. Sta.* 20:1-111.
- Teulings, Robert P., and J. E. Cooper. 1977. Cluster areas. pp. 409-433 in J. E. Cooper, S. S. Robinson and J. B. Funderburg (eds.). *Endangered and Threatened Plant and Animals of North Carolina*, N. C. State Mus. Nat. Hist., Raleigh. xvi + 444 pp.
- Zullo, Victor A., and W. B. Harris. 1979. Plio-Pleistocene crustal warping in the outer Coastal Plain of North Carolina. pp. 31-40 in G. R. Baum, W. B. Harris and V. A. Zullo (eds.). *Structural and stratigraphic framework for the Coastal Plain of North Carolina*. *Carol. Geol. Soc.*, 1979 Field Trip Guidebook. 111 pp.